Pepperdine University

Graduate School of Education and Psychology

AN EFFECTIVE MODEL OF DEVELOPING TEACHER LEADERS IN STEM EDUCATION

A dissertation submitted in partial satisfaction

of the requirements for the degree of

Doctor of Education in Organizational Leadership

by

Heidi Sublette

October, 2013

June Schmieder-Ramirez, Ph.D. – Dissertation Chairperson

This dissertation, written by

Heidi Sublette

under the guidance of a Faculty Committee and approved by its members, has been submitted to and accepted by the Graduate Faculty in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

Doctoral Committee:

June Schmieder-Ramirez, Ph.D., Chairperson

James DellaNeve, Ed.D.

JL Fortson, Ed.D.

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

ACKNOWLEDGEMENTS

I first must acknowledge and am indebted to my family, husband, Scott Sublette, and children, Sydney and Sawyer, for their constant support and sacrifice so that I could pursue this degree. They were there every step of the way along this amazing journey, and I would not have been able to do it without their ongoing love and support.

A very special thanks to my mom who traveled long distances to support me on this journey, and caring for my family and home while I was away. Thank you to all of my friends and family who watched my children or called to check on my progress along the way. Every ounce of support over the last three years did not go unrecognized or unappreciated; it really assisted in my success and completion of this degree.

A sincere thanks to my closest cohort members in the program, Dawn Garrett and Denise Berger, with me from the very beginning and right to the end; this journey was especially meaningful since we were able to share every experience, challenge, and accomplishment along the way. Your encouragement, drive, and friendship will forever enrich my life.

Thank you to my chair, Dr. June Schmieder-Ramirez, for guiding me through this process and pushing me to think further when I thought there was nothing left to say. I appreciate the time and wisdom you offered throughout the entire journey. Thank you to my dissertation committee, Dr. JL Fortson and Dr. James DellaNeve, who were also mentors and wonderful professors. Thank you to LMU and Kathy Clemmer for allowing me to conduct this study with past CMAST participants.

I could not have accomplished this degree without my *family, friends, faculty* and *faith*.

DEDICATION

This dissertation is dedicated to my mother, Susan Hawkins, who has always been a true example of a leader in my life.   She modeled the way for me and her stamina inspired me to push myself beyond the ordinary, she is my inspiration.

ABSTRACT

In the last 5 years, industries have begun to recognize a growing gap in the production of college graduates in areas of STEM. Researchers in various industries believe this gap will create a significant loss of competitive edge in the STEM fields, which will leave the United States pursuing STEM graduates from foreign countries and may ultimately leave the US behind in the industry of science, technology and innovation. This qualitative study analyzes the value and impact of STEM teacher leaders in secondary education. A phenomenological study was conducted with 10 secondary school science and math teacher leaders in order to gain a better understanding of teacher leaders' perceptions, classroom practices and the role of a STEM teacher leader. This study addresses the following research questions: 1) What attributes define effective STEM teacher leaders, according to teacher leaders who have completed the Center for Math and Science Teaching system? 2) What success strategies, among teacher leaders of the Center for Math and Science Teaching program, have enabled further development of teacher leadership? 3) What is the best model in developing teacher leaders, according to literature from 2005 to present? 4) What is an optimal model of developing STEM (science, technology, engineering, and math) teacher leaders within secondary education? This research aims to explore teacher leaders' perceptions of their role as a teacher leader based on strategies learned from CMAST and past experiences. Findings from this study provide critical data for making informed decisions on including important elements when implementing an effective STEM teacher leader system or program, and the impact it can create on science and math teaching and learning in secondary education. The

investigator concludes this study with the development of a STEM teacher leader model that merges these findings with existing research.

Chapter 1: Introduction

As we move through this highly technological evolving time, there is a need for change in education, but specifically in teaching and learning of science, technology, engineering and math (STEM) disciplines in our current K-16 systems. STEM education offers students the necessary skills needed to form inquiry-based learning strategies and critical thinking through thought-provoking projects; STEM is becoming a primary focus in education and industry in the US. For the growth of the US as well as national security, it is imperative that STEM fields and the STEM education pipeline gain the necessary awareness and tools needed. The demand for scientists and engineers is expected to increase by four times the rate over the next decade (California Space Education and Workforce Institute, 2008). Our STEM educators will now have the weight on their shoulders as they focus on producing our future STEM leaders and engineers.

In the Executive Report under President Barack Obama, *Prepare and Inspire: K-12 Education in Science, Technology, Engineering and Math the President's Council of Advisors on Science and Math Education for America's Future*, The President's Council of Advisors on Science and Technology (PRESIDENTS COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY) stated the education system in the US must provide a strong foundation in STEM disciplines (President's Council of Advisors on Science and Technology, 2010). Following this Council are many small and large organizations, state, federal and local leaders spearheading a STEM movement in the US. These proponents of STEM education, as well as industry leaders, believe that increasing math and science requirements in schools, as well as embedding technology and engineering concepts, will better prepare students for advanced education or careers in STEM fields. This would result in the US rising as the world leader of science innovation once again.

The STEM fields have been gaining attention due to the current career gap; there are not enough people to fill the current job market and for the jobs being filled, the skills needed are not meeting industry standards, leading to less than adequate performance. These lack of skills are due to the education and industry gap. The industry standards in engineering are becoming so highly technological and advanced that some universities have not grasped the expansion. It would be highly beneficial for STEM educators to embed laboratory or field experience in their own learning as this change in STEM education evolves.

Due to the demands of the STEM fields, there are emerging groups all over the US providing assistance to K-12 schools, creating awareness and leading change. These groups are an essential piece in the success of STEM development, as they are creating an opportunity for a movement of change in education, and a voice for highly technological students who are ready for a new type of classroom learning experience. Global Employment Trends (2011) reported 77 million youth around the world are unemployed partly due to the lack of necessary skill development. Due to these lack of skills needed in the workplace, businesses and foundations have been pulling together to create new opportunities for both teachers and students, creating opportunities for skill development and designing pathways for a bright future for degree holders.

New Generation Science Standards (NGSS) have emerged from the National Academy of Sciences to build a rich and in-depth curriculum of inquiry based instruction where students build science knowledge year after year, beginning in kindergarten. These standards offer a new look into science and offer students a breadth of discovery among various areas, including engineering and technology. The NGSS were created to better prepare students in STEM by enhancing and integrating the STEM subjects, as well as adding engineering and technology as necessary components of science development. These standards, similar to the Common Core State Standards in Math and English Language Arts recently adopted by California and most states, focus on a more in-depth learning that pushes teachers and students beyond the surface of learning. Additionally, the standards enable students to be problem-solvers, innovators, and self-directed learners; or as the California STEM Learning Network (2012) describes them, "STEM-capable" graduates. The NGSS have not been implemented in the state of California; however, the addition is expected in the 2013 school year.

> These new STEM standards have another important consequence. They have created a "reset button" for policy, providing states the opportunity to re-think curriculum and high-stakes testing, how we prepare and support teachers, and how we deliver high-quality education. In so doing, they offer the promise of breaking down the walls between the classroom and real-world learning experiences. (California STEM Learning Network Forum, 2012)

With this evolving movement comes the issue of who is leading the efforts in this reform. Current classroom teachers in STEM disciplines need support, time, and money to conduct the needed change that is being demanded of them. There have been several initiatives presented by the US government and one is to create a Teacher Leader or Teacher Mentor program.

Loyola Marymount University Center for Math and Science Teaching (CMAST)

This section offers a brief description about this unique Center for Math and Science Teaching (CMAST) system founded by Kathy Clemmer, who began a math and science teaching (MAST) program, while working in her school district. Kathy was considered a master teacher and maintained excellence in the classroom. Kathy collaborated with Loyola Marymount University and together they developed CMAST.

The CMAST system assists in preparing the next generation of STEM teachers who "engage and inspire students to achieve and pursue STEM" disciplines and careers. CMAST offers three programs labeled "systems," to teachers wanting to expand their role at their current school sites: MAST support of Common Core State Standards (CCSS), MAST Teacher Leader Certificate, and Los Angeles Math and Science residency (LAMS). It is important to note that these systems are not creating leaders who plan to leave the classroom in the near future. The program administrators and faculty prefer teachers enrolled in CMAST to remain in their classroom, practicing effective teaching methods of which they are coaching to their peers, while building strong STEM pedagogy. This takes a specific participant, which this research further highlights.

History of the Issue

The US has always been a leader in science innovation and industry with the production of aircraft, spacecraft, and technically advanced systems, but this could potentially change. In the last 5 years, industries began to recognize a growing gap in the production of college graduates in areas of STEM. Researchers in various industries believe this gap will create a significant loss of competitive edge in the STEM fields, which will leave the United States pursuing STEM graduates from foreign countries and may ultimately leave the US behind in the industry of science technology and innovation.

The government has established and confirmed the need for STEM focused programs in the US. The need is evident among most industries by the number of unemployed and the number of jobs available in the US. It demonstrates clear distinction in the lack of skill development in those emerging into the workforce. With this recognition came legislative proposals to assist funding of STEM programs. In, 2007 President Bush signed the America Competes Act, which was passed by the 110th Congress (Kuenzi, Mathews, & Mangen, 2006). This act was a bipartisan legislative response to recommendations detailed in the National Research Council (2007), *Rising Above the Gathering Storm* and the Academy of Science (2007) *Innovate America* report (Thomas & Williams, 2010). The America Competes Act of 2007 was amended and resigned by Obama in 2010. The Act of 2007 was "to invest in innovation and research and development and to increase the competitiveness of the US"(America Competes Act USC, 2007, p. 146). The 2010 Act has added several more components to increase funding and expand authorization of committees involved in STEM and business fields.

There have been several initiatives presented by the US government, and in addition to the America Competes Act, another is to create a teacher leader or teacher mentor program, called STEM Master Teachers Corp (President's Council of Advisors on Science and Technology, 2010). "The President's plan would begin with 2500 teachers, 50 in 50 sites across the country and locations over the next four years until there are ten thousand teachers in this sector" (President's Council of Advisors on

Science and Technology, 2010). This initiative has shed some light on individual states and currently California is part of the 100 thousand in 10 initiative and movement led by the federal government. This movement is to create one hundred thousand effective STEM teachers in ten years (California STEM Learning Network Forum, 2012). Many states have also jumped on this movement and there are websites, campaigns, and ads throughout the US advertising this movement. It is now reaching businesses and industries in need of graduates.

The business community has become more and more active in the last few years, because they claim that the nearly 200,000 students who graduated in STEM disciplines in 2004 are not an adequate amount to meet the demands of the science and technology industry. The concern is growing due to hundreds of thousands of students graduating in the STEM disciplines; thousands are not adequately prepared or have the skill development needed to perform the job (Elrod, 2010). Skill development reflects on the university programs educating students in STEM disciplines.

According to Tsupros, Kohler and Hallinen (2009), “STEM education should be instructed using an integrated method of science, technology, engineering, and mathematics in contexts that connect school, communities, and global enterprise for developing STEM knowledge.” A STEM curriculum should be facilitated by presenting real-world problems, driving students to apply STEM learning to create and engage in rich experiments, analyze and interpret data, and deliver authentic findings (Wineberg & Grossman, 2000).

Statement of the Problem

There is a strong need for education reform in science and mathematics throughout the US. The US has been the leader of science innovation for the last century, and other countries may soon overtake it if STEM education does not become a major concern throughout this country. According to the STEM Education Coalition 2008 Report Card over the last decade the percentage of ACT-tested students who stated they had an interest in majoring in engineering has dropped from 7.6 to 4.9 percent, and those majoring in computer science has dropped from 4.5 to 2.9 percent (California STEM ED Coalition, 2008). It has also been discovered that students most likely to major in STEM fields in college and earn a degree, are well prepared in high school with challenging classes and college-level science and math coursework (California STEM Ed Coalition, 2008). This means that students should ideally identify and follow a science path prior to middle school.

In a study conducted using a data set collected by the National Center for Educational Statistics, it was found that students who reported a career interest in a science-related field in eighth grade were two to three times more likely to earn a STEM degree ten years later (PLTW.org). In a national survey of over 4,000 scientists and graduate students in the fields of chemistry and physics, researchers found that nearly 70% reported that they first became interested in science in middle school (National Research Council, 2007, p. 10).

Rigorous and engaging coursework will most likely lead to a successful outcome in the STEM disciplines and fields during high school; however, it has been discovered that many science teachers today are still using 19th century teaching methods for STEM disciplines. There is a need for change with such technological advances. Our current education system still highly focuses science and math in secondary education as single instructed subjects, but there is a call for integrating technology and engineering in the current science and math frameworks. STEM students need inquiry based instruction methods, allowing them to gain conceptual knowledge along with the development of critical thinking skills; these skills may be better developed when the subject of science is merged with engineering, technology and math. There are currently an abundance of science and math teachers using textbooks as the primary learning tool, rather than an inquiry-based or reasoning model and an opportunity for exploration and discovery.

In a recent 2011 study, conducted by 27 graduate students in a STEM leadership program, students questioned their teacher colleagues and administrators on defining STEM. A survey was utilized and resulted in approximately half of 200 teachers surveyed were able to identify the STEM acronym, half of all administrators could define STEM education, and about 60 percent of science teachers could describe STEM education (Brown, Brown, Reardon, & Merrill, 2011). This raises an issue of a lack of awareness among educators on the STEM focus in the US as well as a clear definition of STEM.

Statement of the Purpose

The purpose of this study is to research the Loyola Marymount CMAST system, focused on science and mathematics teaching and learning methods in secondary classrooms. The research developed from this study provides an analysis on secondary math and science teachers emerging as teacher leaders to change and sustain STEM-based instruction. Engaging teachers as teacher leaders to impact student learning and create sustainable change, is an area with minimal research. This study will identify an effective model of leading and preparing secondary teachers of STEM disciplines in the state of California to better prepare students to enter STEM disciplines and fields.

The research further examines the education of our current secondary teachers with an opportunity to further develop their knowledge of STEM teaching and learning methods through teacher leaders. This research will provide depth on how we can better equip current secondary classroom STEM teachers with opportunities for professional development and leadership. The outcomes of this study will enhance the development of the teaching and learning of STEM in secondary classrooms and may assist STEM teacher preparation development among other post-secondary institutions.

Recent Statistics on the Topic

The National Academy of Science, National Academy of Engineering, and Institute of Medicine of the National Academies, (NSF, 2006) has tracked data from many countries on the amount of university degrees awarded in STEM fields. This data concludes the US has one of the lowest rates of STEM to non-STEM degree productions in the world. "STEM degrees accounted for 16.8 percent of all university degrees awarded in the US compared to 46.7 percent in China, 37.8 in South Korea, and 28.1 percent in Germany" (NSF, 2006). The international average of this same ration was 26.4 percent in 2002.

The American Council on Education Fellows, all with backgrounds in STEM fields, has created a mission of preparing the next generation of STEM leaders. The STEM pipeline narrows significantly from 9th grade through college graduates. A study conducted by the National Science Board followed a 10 year pipeline and began with STEM engagement in 1997 with 3.8 million 9th graders, narrowing to 2.7 million high school graduates in 2001 to 1.7 million college freshman to only 233,000 STEM graduates in 2007 (National Science Board, 2010). This shows that about 70% of STEM focused students who enter college as freshman have changed their major out of STEM disciplines upon graduation.

Further statistics from Global Employment Trends 2011 reported 77 million young adults around the world are unemployed partly due to the lack of necessary skill development. Due to these lack of skills needed in the workplace, businesses and foundations have been pulling together to create new opportunities for both teachers and students, creating opportunities for skill development, and designing pathways for a bright future for degree holders. Furthermore, a recent report developed and published by a national nonprofit research group called Change the Equation, stated California has nearly 1.5 open jobs in STEM fields for every qualified job seeker. California additionally has the third highest unemployment rate in the nation (California STEM Learning Network, 2012).

In addition to the lack of skilled STEM employment candidates, “California students are among the lowest performing and least-funded, with fewer students earning degrees in STEM fields when compared to other states.” California has nearly one million STEM workers and an expected 19 percent growth rate in STEM jobs over the next decade; however, the state is only producing an estimated 21,000 STEM bachelor’s degrees annually, with only one in 10 degrees or certificates awarded in STEM fields (California STEM Learning Network, 2012). Among these statistics, are an extremely low percentage of minors and women represented in STEM fields and/or disciplines.

Research Questions

STEM integration into our current math and science classrooms is urgent and necessary. This study will explore additional research needed to gain understanding on identifying the attributes that create effective secondary STEM classroom teachers. The following research questions will guide this study:

1. What attributes define effective STEM teacher leaders, according to teacher leaders who have completed the Center for Math and Science Teaching system?
2. What is the best model in developing teacher leaders, according to literature from 2005 to present?
3. What success strategies, among teacher leaders of the CMAST program, have enabled further development of teacher leadership?
4. What is an optimal model of developing STEM (science, technology, engineering, and math) teacher leaders within secondary education?

Significance of the Topic

The current STEM movement has reached a state and national level. For this reason, it is necessary to keep the momentum of this trend and to spark the necessary education reform in US classrooms. Additionally, the US is approaching a large displacement of teachers due to upcoming retirement plans of Baby Boomers. This is a perfect opportunity for STEM education reform to occur as universities begin placing future teachers in US classrooms.

The significance of this study is based on a great need to improve teacher recruitment, preparation, retention, and renewal. The Science, Technology, Engineering and Math Collaborative Action Plan (STEM CAP) was designed by government, academia, and industry leaders to strategically identify STEM priorities. This collaboration resulted in an analysis of influential STEM related state and national reports written and commissioned by the Business-Higher Education Forum, US Department of Education, Business Roundtable, National Science and Technology Council, Council on Competitiveness, Congressional Research Service, National Governors' Association, US Department of Labor, National Science Board, National Action Plan and others, as well as the results of the three California Space and Engineering Workforce Institute forums and the STEM CAP focus groups (California STEM Ed Coalition, 2008). At its August, 2007 meeting, the STEM CAP Advisory Group reviewed the recommendations from the 22 most cited National and State reports on STEM. One hundred plus recommendations were placed into ten categories, with the focus on teaching and student learning as the top two:

1. "Teacher recruitment and preparation
2. Teacher retention and renewal
3. Student recruitment
4. Curriculum
5. Promising practices/data
6. Strategic communication/marketing
7. State policy/leadership
8. Business collaboration
9. Coordination/articulation
10. Finance" (STEMCAP, 2008)

California has had an immense decrease in the number of students majoring in teacher education. More than 20,000 K-12 teachers have been laid off in the last several years, which have led to enrollments in teacher preparation programs down by half over the last three years (California STEM Learning Network, 2012). The high number of K-12 teachers laid off has created a deterrent for college graduates to enter the teaching field. There are currently a number of university programs pulling prospective STEM teachers from the math and science majors, providing incentives to enter the teaching workforce to increase the quality of STEM education. The state of California educates nearly one in eight students nationally, and despite fewer resources, achievement levels among California's six million students have been increasing steadily (T. Torlakson, personal communication, October 16, 2012).

This research provides critical data for making decisions about the direction for STEM teacher education programs both at the teacher level or master's level, the undergrad level, and STEM teacher professional development programs. The results also present to practitioners, administrators, researchers, and policymakers the role of STEM in science and math education reform in the coming years. This study is critical to how we measure classroom learning with STEM based practices, and this is an area of research that hasn't been assessed in the past.

Key Definitions

Several new terms may arise in the remaining chapters of this study and may have interpreted meanings. The following are key definitions of these terms to guide the reader: